Gambacorta Marsh Dike Operation and Maintenance Manual

City of New Castle, Delaware

Prepared on:_____
Reviewed and Updated on:_____

_____	_____
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Copy: ____ of ____

Prepared by:

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PART I: BACKGROUND DATA

A. Introduction

Gambacorta Marsh Dike is located along the Delaware River south of Battery Park and north of the Army Creek Dike in the City of New Castle, New Castle County, Delaware. The dike can be accessed by vehicle or foot from the paved path that begins at Battery Park. The dike protects wetlands and structures (homes and businesses) in low lying areas from flooding caused by the Delaware River. This Operations and Maintenance ("O&M") Manual has been prepared for those who will operate and maintain the dike.

The Gambacorta Marsh Dike is part of the flood protection system for the City of New Castle. The flood protection system consists of four dikes, adjacent to the Delaware River that generally extend north to south; the Buttonwood Dike, the Broad Marsh Dike, the Gambacorta Marsh Dike, and the Army Creek Dike. The dikes protecting the City of New Castle are reportedly the oldest in the United States with their original construction date in the 1600's by Dutch settlers.

Physical Description of the Dike

Item	Location	Description
Dike	along the Delaware River south of Battery Park and north of the Army Creek Dike in the City of New Castle, New Castle County, Delaware	Length: 1,600 feet Height: Approx. 6-8 feet Width: 8-12 feet
Bank / Slope Protection	Wetland side = Protected side (PS) River side = Flood side (FS)	Riprap placed unevenly on portions of the FS slope Vegetation on the PS slope
Tide Gate	Located in the tide gate vault	one 36" self-regulating tide gates
Tide Gate Vault	Located approximately 200 feet south of Battery Park	Bottom Elev: unknown Top Elev.: unknown Width x Length: unknown
Tide Gate Vault Pipes	Extending FS and PS from the tide gate vault	Inlet (FS): 1 @ 36" Diam. RCP Outlet (PS): 1 @ 36" Diam. RCP

B. Description

A visual inspection of the dike was performed by Green Stone Engineering and Schnabel Engineering in March and April 2010. The inspection of the dike was

performed to evaluate and identify the overall level of maintenance, encroachments, animal burrows, vegetation, condition of the top of dike, evidence of erosion on and adjacent to the dike, excavations in or adjacent to the dike, evidence of settlement, seepage, piping, sloughs or other forms of instability. This Operation & Maintenance (O&M) Manual will provide a mechanism by which remedial repairs and routine maintenance items can be performed to avert long-term degradation of the embankments.

C. Project History

As indicated in Part 1.A., it is thought that the dike was originally constructed in the 1600's. There have reportedly been a number of improvements made to the dike since its original construction resulting in its current configuration. There are no known design or construction documents for the original dike construction or subsequent dike improvements.

Installation of a self-regulating tide gate that controls the movement of water through the dike was completed within the past 10 years. Design and as-built documents for the self-regulating tide gate are not available.

A detailed visual inspection and evaluation was performed for the dike in 2010.

The dike was evaluated and documented according to the rating criteria established by pertinent sections of the United States Army Corps of Engineers (USACE) Flood Damage Reduction Segment / System Inspection Report, which is presently used for performing and documenting Periodic Inspections (PIs) for the USACE Levee Safety Program. Guidance on the criteria used is described in USACE Levee Owners Manual for Non-Federal Flood Control Works (FCW), The Rehabilitation and Inspection Program, Public Law 84-99, March 2006 (USACE 2006). Supplemental guidance used in the evaluation of vegetation was drawn from ETL 1110-2-571, Engineering and Design: Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures (USACE 2009).

A detailed report developed as part of this inspection/evaluation is on file at the City of New Castle.

Improvements made to Gambacorta Marsh Dike after the date of this manual should be added to this section upon completion. In addition, records or construction documents associated with future dike improvements should be kept on file at the City of New Castle.

D. Contracts and Miscellaneous Correspondence

A record of routine or corrective maintenance performed on the dike will be kept and included as a part of this manual. This section shall contain an ongoing

record of relevant contracts and correspondence related to operation and maintenance of the dike. It shall include correspondence from regulatory agencies regarding compliance issues and professional services. This section shall be reviewed and updated annually along with the entire O & M manual to incorporate pertinent correspondence.

E. Glossary of Terms

The following terms are provided so that those responsible for operation and maintenance of the dike will be familiar with terms relating to the dike.

Appurtenant Structures – Ancillary features of a dike, such as the pipes, tide gates and vaults.

Boil - Stream of seepage water carrying silt and sediment and rising as a spring in a depression – on FS or PS of dike

Crest – The term “crest of dike” is often used when “top of dike” is meant.

Dike – A natural or artificial slope or wall to regulate water levels.

Drainage Area – The area that drains naturally to a body of water.

Embankment – A slope of fill material, usually earth or rock that is longer than it is high or the sloping side of a dike.

Flood Side (FS) - Delaware River side of the dike.

Homogeneous Earthfill Dike – An embankment dike constructed of similar earthen material throughout.

Freeboard – The vertical distance between a known water surface elevation and the top of a dike.

Tide Gates – Structures that control the flow of water through a dike.

Piping - The progressive development of internal erosion by seepage, appearing downstream as a hole or seam discharging water that contains soil particles.

Rip rap – A layer of large stones, broken rock, or precast blocks placed in random fashion on the slope of an embankment dike as a protection against wave action or erosion. Very large rip rap is sometimes referred to as armoring.

Overtopping - Flow of water over the dike crest.

Protected side (PS) - marsh side of the dike

Seepage – The internal movement of water that may take place through small spaces in a dike or its foundation.

Toe of Dike – The junction of the downstream face of an embankment with the ground surface.

Wavewash - Erosion of the dike slope by wave action (high wind and wave conditions).

PART II: OPERATION AND MAINTENANCE

A. General

A well organized O&M program will protect the dike against deterioration and prolong its life. All components of the dike, including the embankment and tide gates, are susceptible to deterioration over time. This manual establishes a basic O&M program based primarily on systematic inspections. During each inspection a checklist of items, as defined in Inspections and Inspection Checklist (Part II, Section E), must be used. The completed checklist must be dated and signed by the "Inspector" and incorporated into this manual.

This manual is intended as a guide and outlines the proper procedures for conducting routine O&M for the dike. A key site person ("Inspector") should be appointed to perform inspections for any given year. This manual will then be transferred yearly to the appointed "Inspector." A continuous record of the O&M for the dike must be maintained. The Designated Inspectors List (Part II, Section B) lists the responsible entities and various contractors. This section must be updated periodically pending a change in the Inspector, the Engineer, or the Contractor.

At least two (2) copies of this manual shall be kept by the City at all times. All correspondence and dike maintenance checklists shall be reproduced in triplicate and distributed for inclusion into the manuals. One (1) copy of this manual along with all updates and inclusions shall be forwarded to the *Dike Safety Governing Body* if such an entity is ever established in Delaware.

This section of the manual has been prepared to provide the Inspector with a simple and systematic method for inspecting, operating and maintaining the dike. For the most part, the O&M for the dike involves observation rather than evaluation. The following sections provide a step-by-step procedure to assist the Inspector in performing all duties in a rational and orderly manner. The Inspector must become familiar with the background information in Part I of this manual. The Inspector must also review the plans which are listed in Part II, Section C. Finally, prior to conducting an inspection or performing routine O&M, the Inspector must review the Tools and Equipment List (Part II, Section D) and the Inspections and Inspection Checklist (Part II, Section E) of this manual. Each time an inspection reveals the need for maintenance, the Inspector shall notify the City of New Castle who may hire a contractor to perform the work under the direction of a qualified Delaware Licensed Engineer. Each time maintenance is performed on the dike, the Inspector must record the incident and place a copy of the maintenance checklist in this manual Part II, Section F. Inspections must be performed once every year between March and May and after each major storm event. Routine maintenance, as defined in Part II, Section F, shall be performed immediately after each inspection and after each major storm event.

B. Designated Inspectors List

This Section must be updated periodically to reflect the name(s) and telephone number(s) of the appointed Inspector(s), Professional Engineer and Contractors

	Organization	Office Address	Contact	Phone No.
Inspector				Office: Cell:
Professional Engineer				Office: Cell:
Designated Contractor				Office: Cell:

C. Plan Review

This section identifies existing plan documents. These documents can be found on file with the City of New Castle. This section shall be periodically updated to incorporate additional plans and sketches that are developed for the operations, maintenance, inspection or rehabilitation of the dike and its ancillary features. The Inspector shall review available plans prior to conducting an inspection of the dike.

D. Tools and Equipment

The following is a list of required inspection equipment for routine O&M procedures and Inspections.

a. A clip board, a pencil and the inspection checklist – the inspection checklist is included in the following section.
b. A standard 6-foot collapsible ruler.
c. A camera – photographs of observed portions of the dike will provide a measure of performance when comparing past and present maintenance practices or conditions.
d. A probe – any stiff light stick or rod with a blunt tip of sufficient strength to penetrate soil. The probe can provide information on conditions below the surface of the dike such as the depth and softness of a saturated area.
e. A weed whacker – can be used to clear non-visible areas and to perform routine maintenance on the embankments.
f. A flashlight – a flashlight can be used to observe the inside of pipes and the tide gate vault.

Maintenance at the dike may include heavy equipment including the following:

a. Chain Saw
b. Stump Grinder
c. Lawn Mower(s)

d. Excavator
e. Bull Dozer
f. Dump Truck
g. Pump

Sources of the following materials should be identified for immediate use if warranted by the inspection:

a. Native, silty sand for filling erosion rills and gullies.
b. Topsoil mixture, fertilizer and seed.
c. Large stone rip rap for emergency repairs caused by erosion.
d. Biodegradable erosion control matting and stakes to prevent seed and top soil from erosion.

E. Inspections and Inspection Checklist

Prior to performing inspections, the Inspector must observe the water level FS and PS of the dike. The inspections must occur at low tide of the Delaware River. Inspecting at low tide allows the Inspector to freely observe the entire FS and PS slopes.

The most effective means of conducting the inspection is to treat each dike component as an individual element, inspect it thoroughly, and fill out the checklist prior to moving on to the next element. The checklist sequence for inspection of each dike element is as follows:

a. The crest: walk along the top of the dike from one end to the other and look for erosion, puddles, settlements, cracks in the paved or unpaved surface or animal burrows, etc.
b. The FS embankment: walk along the FS of the dike in a zigzag, top to bottom fashion and to the water's edge and observe erosion, puddles or wet areas, slumps, woody vegetation or animal burrows.
c. The PS embankment: walk along the PS face of the dike in a zigzag, top to bottom fashion to observe any erosion, puddles or wet areas, slumps, woody vegetation or animal burrows.
d. The tide gate vault: Observe the condition of the inlet/outlet culverts at the FS and PS headwalls. Check the condition of the RCP pipes to note any blockage or cracks. Check the condition of the outside and inside of the concrete tide gate vault, identify cracks, spalling, deterioration, etc.
e. Observe the condition of the tide gates. Check the gate to ensure it is functioning properly.

The inspection checklist included in this section should be copied and completed every time an inspection is performed. After each inspection, the Inspector will report to the City of New Castle, which will direct maintenance operations as necessary.

Gambacorta Marsh Dike Inspection Checklist

Inspector:_____ Date: _____

Weather Conditions:_____

Observed Item	Yes	No	N/A	Dimensions, Locations, Comments, etc.
Access:				
a. Vandalism?				
b. Signage?				
c. Security?				
d. Crest road intact?				
e. Obstructions to access?				
Crest (Walk along the top of the dike from one end to the other)				
a. Cracks? (how long?)				
b. Ruts or holes? (how big?)				
c. Erosion gullies?				
d. Bare areas?				
e. Animal Burrows?				
f. Trees? (how many?)				
g. Slumps or settlements?				
h. Wet areas or seepage?				
i. Vegetation overgrowth?				
FS Embankment (start at top and walk up and down slope across entire dike)				
a. Cracks? (how long?)				
b. Ruts or holes? (how big?)				
c. Erosion gullies?				
d. Bare areas?				
e. Animal Burrows?				
f. Trees? (how many?)				
g. Slumps or settlements?				
h. Wet areas or seepage?				
i. Vegetation overgrowth?				
PS Embankment (start at top and walk up and down slope across entire dike)				
a. Cracks? (how long?)				
b. Ruts or holes? (how big?)				
c. Erosion gullies?				
d. Bare areas?				
e. Animal Burrows?				
f. Trees? (how many?)				
g. Slumps or settlements?				
h. Wet areas or seepage?				
i. Vegetation overgrowth?				

Tide Gate Vault and Headwalls				
a. Deterioration of Concrete? (where?)				
b. Cracks in concrete? (where?)				
c. Exposed rebar?				
d. Leaks into vault?				
e. Access hatches intact?				
f. Access hatch locked?				
Vault Inlet/Outlet Pipes				
a. Cracks?				
b. Blockage?				
c. Erosion around pipe?				
Tide Gate				
a. Damage?				
b. Attached to vault properly?				
c. Blockage?				
d. Functioning properly?				
Recommendations For Maintenance:				

Gambacorta Marsh Dike Inspection Occurrences

Type of Inspection	Inspection Items	Operation Duties
Low tide inspections	• Conducted at least once annually	• See Inspection Checklist.
High water patrol inspections	• Conducted during floods and high water events. • Monitor the performance of the tide gates. • Monitor FS and PS slopes for erosion, slumps, etc.	• Organize dike patrols, if required. • Initiate or take corrective action as required.
Post Flood	• Conducted after a flood event.	• Develop high water profile. • See Inspection Checklist.

F. Operation and Maintenance and Routine Maintenance Checklist

There are three (3) categories of maintenance: immediate maintenance, corrective maintenance, and continuing maintenance. Accordingly, each of the maintenance conditions will be determined during the annual inspection. This portion of the report also contains a section on technical guidance describing corrective action.

a. Immediate maintenance demands immediate attention, requires notification of the *Dike Safety Governing Body*, and must be performed under the supervision of a qualified Delaware licensed professional engineer. Immediate maintenance usually requires construction equipment. Immediate maintenance can be characterized but not limited to the following:
   i. A severe slope failure.
   ii. A breach or near breach caused by severe progressive erosion.
   iii. Overtopping of the crest by FS or PS waters.
   iv. Structural damage to tide gate or tide gate vault.
   v. Increasing uncontrolled seepage through the embankment.
   vi. A blocked tide gate or inlet/outlet pipe.

b. Corrective maintenance should be performed as soon as possible after an inspection. Corrective maintenance consists of but is not limited to the following:
   i. Clearing of trees, shrubs and underbrush on the dike embankments or crest.

ii. Filling eroded areas or gullies and seeding to stabilize the area.
iii. Removal of burrowing animals and filling the holes.
iv. Resetting the level of the self regulating tide gate

Corrective maintenance can be performed by volunteers with some technical guidance.

c. Continuing maintenance will occur on a regular basis and can be performed during informal inspections or in accordance with maintenance schedule outlined in Part II, Section G of this manual. Continuing maintenance includes:

i. Observation of any wet areas, springs or potential seepage in the embankment.
ii. Removing small shrubs or underbrush on the dike embankment.
iii. Filling small eroded gullies.
iv. Filling of ruts caused by pedestrian traffic along the crest.
v. Removing accumulated trash and debris.
vi. Removal of burrowing animals and their dens from the dike.
vii. Fertilizing and overseeding grassed areas.
viii. Mowing grass areas.

Continuing maintenance can be performed by the Inspector, contractors or volunteers on an ongoing basis.

d. Technical Guidance (Embankment Vegetation)

The first maintenance requirement is to keep the crest and FS/PS embankments free of unwanted vegetation (woody vegetation and weeds). Excessive vegetation growth and/or growth of woody plants or weeds are harmful in the following ways:

1. It can obscure view of the embankments and prevent a thorough inspection for possible cracks or other evidence of problems on the dike.
2. Large trees could be uprooted during a storm and the resulting large hole left by the root system could lead to breaching of the dike.
3. Some root systems can decay and rot resulting in piping.
4. Weeds can discourage growth of desirable grasses.

Grass on the crest and FS/PS slopes should be kept at a height of approximately 6-8 inches.

e. Technical Guidance (Animal Burrows)

Animal burrow control is a key feature of the O&M of the dike. Rodents such as woodchucks, muskrats, ground squirrels, rabbits, moles, and

beavers endanger the structural integrity of the embankment. Animal burrows are easily recognized in the spring because fresh soil is generally found at the mouth of the burrows. Early detection and control in April is essential in controlling burrowing activity. Muskrats are nocturnal and can be found in marshy areas. Their burrows are difficult to detect since they tend to burrow below the water line. Beaver activity will become apparent through visual observation of tree cuttings. Animals should be removed immediately upon detection. Woodchucks, squirrels, rabbits, moles and muskrats can be exterminated or flushed out with smoke. Beavers must be relocated. The animal burrow must be filled with soil or a mixture of water to 9 parts soil and 1 part cement. The soil mixture should be placed as deep as possible and compacted with a pole.

Gambacorta Marsh Dike Continuing Maintenance Checklist

Maintenance Crew:_____ Date: _____

Weather Conditions:_____

Maintenance Item	Yes	No	Location and Equipment Used
Vegetation Control			
a. Mow/trim grasses			
Crest:			
a. Remove trash			
b. Fill ruts and holes			
c. Fill potholes in pavement			
d. Remove trees and shrubs, etc.			
FS Slope:			
a. Remove trash			
b. Fill ruts, holes and gullies			
c. Fill and compact animal burrows (remove rodents)			
d. Remove trees and shrubs, etc. (10 feet from mow line)			
e. Fertilize and overseed grass areas			
f. Replace stone rip rap			
PS slope:			
a. Remove trash			
b. Fill ruts, holes or gullies			
c. Fill and compact animal burrows (remove rodents)			
d. Remove trees and shrubs, etc. (10 feet from mow line)			
e. Replace missing riprap			
f. Replace stone rip rap			
Inlet/Outlet Pipes			
a. Clean out debris			
b. Patch joints			

G. Schedule of Inspections and Maintenance

The following schedule shall be for the minimum requirements for inspections (see checklists in Section E). Inspections must be performed once every year between March and May and after each major storm event. Routine maintenance, as defined in Part II, Section F, shall be performed immediately after each inspection and after each major storm event.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Annual Inspection												
Low Water Patrol Inspection												
Maintenance												
a. Removing small shrubs or underbrush on the dike embankment[1]												
b. Filling small eroded gullies												
c. Filling of ruts caused by pedestrian traffic along the crest												
d. Removing accumulated trash and debris[2]												
e. Removal of burrowing animals and burrows[3]												
f. Fertilizing and overseeding grassed area												
g. Mowing grass areas[4]												

[1] Removing small shrubs or underbrush on the dike embankment should occur at least two times per year as needed

[2] Removing accumulated trash and debris should occur every two months.

[3] Removal of burrowing animals and burrows should occur at least two times per year (Once in April and once in August)

[4] Grass on the crest and FS/PS slopes should be mowed as needed to be kept at a height of 6-8 inches

a. Summary of Emergency Conditions and Repair

Emergency Condition	Definition	Problem	Repair
Active boil	Stream of seepage water carrying silt and sediment and rising as a spring in a depression – on FS or PS of dike	Sudden failure due to undermined dike foundation.	Construction of an impervious ring around boil to stop transportation of solid material.
	Contact emergency organization if (1) active boils extensive, (2) inactive boils and water levels rising. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE FAILURE IS POSSIBLE.		
Slope Seepage (excessive)	Percolation of water through or under the dike foundation,	Sloughing of embankment, threatening dike stability.	Add free draining fill berms where slope soggy.
	Obtain expert advice on slope stability where time permits. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE FAILURE IS POSSIBLE.		
FS or PS Erosion	Erosion of FS or PS slope of dike.	Removal of dike material under the water surface resulting in dike failure.	Additional bank protection (such as large riprap). End dumping acceptable in emergency situation only.
	Obtain expert advice on bank protection and stability where time permits. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE BREACH IS POSSIBLE.		
Wavewash	Erosion of the dike slope by wave action (high wind and wave conditions).	Removal of exposed materials causing breach or near breach.	Placement of protective material or filled sacks. Patrol identified areas and monitor closely.
	Obtain expert advice on likely locations of wavewash prior to high water. IMPLEMENT EMERGENCY RESPONSE PLAN IF DIKE BREACH IS POSSIBLE.		
Local Overtopping	Flow of water over the dike crest.	Breach of dike due to wash out of crest material once overtopping occurs.	Sandbags for raising short sections of the dike. Other methods of adding material for longer dike sections.
	IMPLEMENT EMERGENCY RESPONSE PLAN IF OVERTOPPING OR BREACH IS POSSIBLE. No heavy equipment on dike when water level is high.		

Part III: Contact Information Table

Regional and Local Contact Names and Agencies

Organization	Office Address	Representative	Phone No.
City of New Castle	220 Delaware Street New Castle, DE 19720	Cathryn Thomas	Office: 302-322-9801
City of New Castle Dike Operator	220 Delaware Street New Castle, DE 19720	Jeff Bergstrom	Office: 302-322-9813
New Castle County Emergency Services	3601 N. DuPont Hwy. New Castle, DE 19720	Dave Carpenter	Office: 302-395-2700
Delaware Emergency Management Agency (DEMA)	165 Brick Stone Landing Rd. Smyrna, DE 19977		Office: 302-729-3362
City of New Castle Emergency Management	220 Delaware Street New Castle, DE 19720	John Lloyd	Office: 302-420-2684
Green Stone Engineering	5600 Kirkwood Highway Wilmington, DE 19808	Bruce W. Jones, PE	Office:302-998-4401